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PRELIMINARY REPORT ON STRATASTIR.(U)
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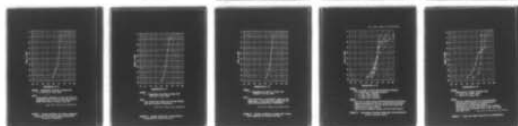
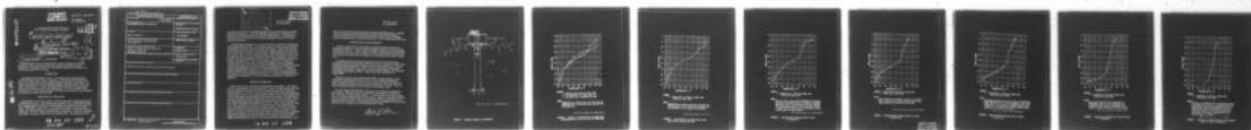
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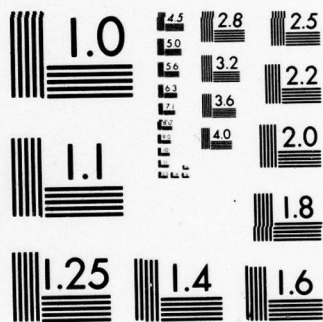
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U. S. Navy Underwater Sound Laboratory
Fort Trumbull, New London, Connecticut

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PRELIMINARY REPORT ON STRATASTIR

by

Charles F. Gerber

USL Technical Memorandum No. 954-124-62

19 September 1962

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DEFINITION

STRATASTIR is a device designed to effect a radical reduction in the thermal gradient of a land-locked body of water deep enough to be stratified by natural environment. The name of this device is derived from its theoretical operation: the mixing or stirring of water strata.

BACKGROUND

The Dodge Pond Field Station of the U. S. Navy Underwater Sound Laboratory is located at Dodge Pond in Niantic, Connecticut. The operation of this field station, which is one of the largest and best equipped transducer facilities in the country, has always been hampered by a large temperature gradient during the months of June, July, August, and September. At times, adjustments were necessary to correct measurements for the detrimental effects of the large gradient. The over-all gradient often approached 40° F. within the 40-foot depth of the pond with the gradient nearing 3 degrees per foot at the test depth ordinarily used.

DESCRIPTION OF STRATASTIR

STRATASTIR is a vertically-oriented, axial-flow pump with a design capacity of two million gallons per hour. Its total head, which is about 0.4 psi, is completely absorbed by the pumping losses since the water being pumped is never taken above the level of the pond. STRATASTIR, seen in Fig. 1, is far removed from the usual areas of pump design. The pump is housed in a 4-foot-diameter vertical tube. A flared inlet reduces inlet losses. The outlet, which is below the surface of the water, consists of an external flare similar to the inlet, and an inner reversed-ogive flare. The combination of the

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two changes the direction of the discharged water from vertically upward to radially outward in all directions. The whole assembly is supported on an independent 13-foot-square float constructed from four standard Navy pontoons. It is powered by a 20-hp electric motor which drives the pump by appropriate v-belt and worm-gear reduction components.

STRATASTIR was designed for a velocity of 6 feet per second and a pumping rate of two million gallons per hour. Its discharge velocity is also 6 feet per second with the discharge cross section equal to the tube cross section. This minimum velocity of 6 feet per second was chosen to provide good submerged mixing of the discharged water with the water near the surface of the pond. Submerged mixing was chosen for two reasons: first, to provide maximum efficiency by not requiring the pump to raise the water above the level of the pond surface; and second, to eliminate, as much as possible, the mixing of additional air into the water. STRATASTIR was mounted on a float for two reasons also. First, the float allows mobility if it is necessary to (1) affect all parts of the pond and (2) remove the equipment from the immediate vicinity of the testing area. Second, the depth of discharge can be changed by pumping water into the pontoons of the float for lowering and pumping it out for raising to provide a discharge depth range of 3 to 5-1/2 feet below pond level. A controllable telescopic section of the inlet pipe allows about 8 feet of over-all length adjustment for the unit to provide any height from 26 to 34 feet. Provisions for adjustments were designed into the equipment in order to determine the most effective conditions of operation.

THEORY OF OPERATION

Matter, free to move, will move until its position is most stable. In the case of water, we note that water will seek its own level. Thus, in a body of water, quantities of water at different temperatures will flow or otherwise move until the heaviest (coolest down to 4° C. or 39.2° F.) water is at the lowest level, and all other densities (temperatures) of water will arrange themselves relative to their density (temperature) with the temperature increasing upward to the surface of the pond. This phenomenon produces a normally stratified condition that will be found in almost any body of water, particularly during the summer months after the sun and warmer air temperatures have raised the average water temperature over 40° F. Now, if water from the colder, more dense, lower levels is raised to or near the surface of the stratified body of water and released in low velocity non-turbulent volumes, it will flow or move back to the lower levels where the density of the stratum it returns to is equal to its own density. If, however, this colder more dense water is mixed with warmer, less dense water near the surface, the resultant volume of water will be at some intermediate temperature, dependent upon the quantitative rate of mixing, and, because of its density, will seek and find its level in the stratified structure (restratification, if you

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wish, but with different volumes and depths of strata) of the body of water. Continuation of the pumping-mixing-restratification process should eventually result in virtually a single stratum at equilibrium temperature and density with this single stratum encompassing the total body of water; in other words, complete destratification.

ABBREVIATED LOG OF OPERATION

A 4-hour run was made on 19 July 1962, as a general check on electrical and mechanical capabilities. Periodic temperature-depth records were made during and following the 4-hour run. Figure 2 shows the changes in temperature at various depths resulting from this short run and includes a third curve taken several hours after the run to indicate the permanency of the change in the stratification of the water at Dodge Pond.

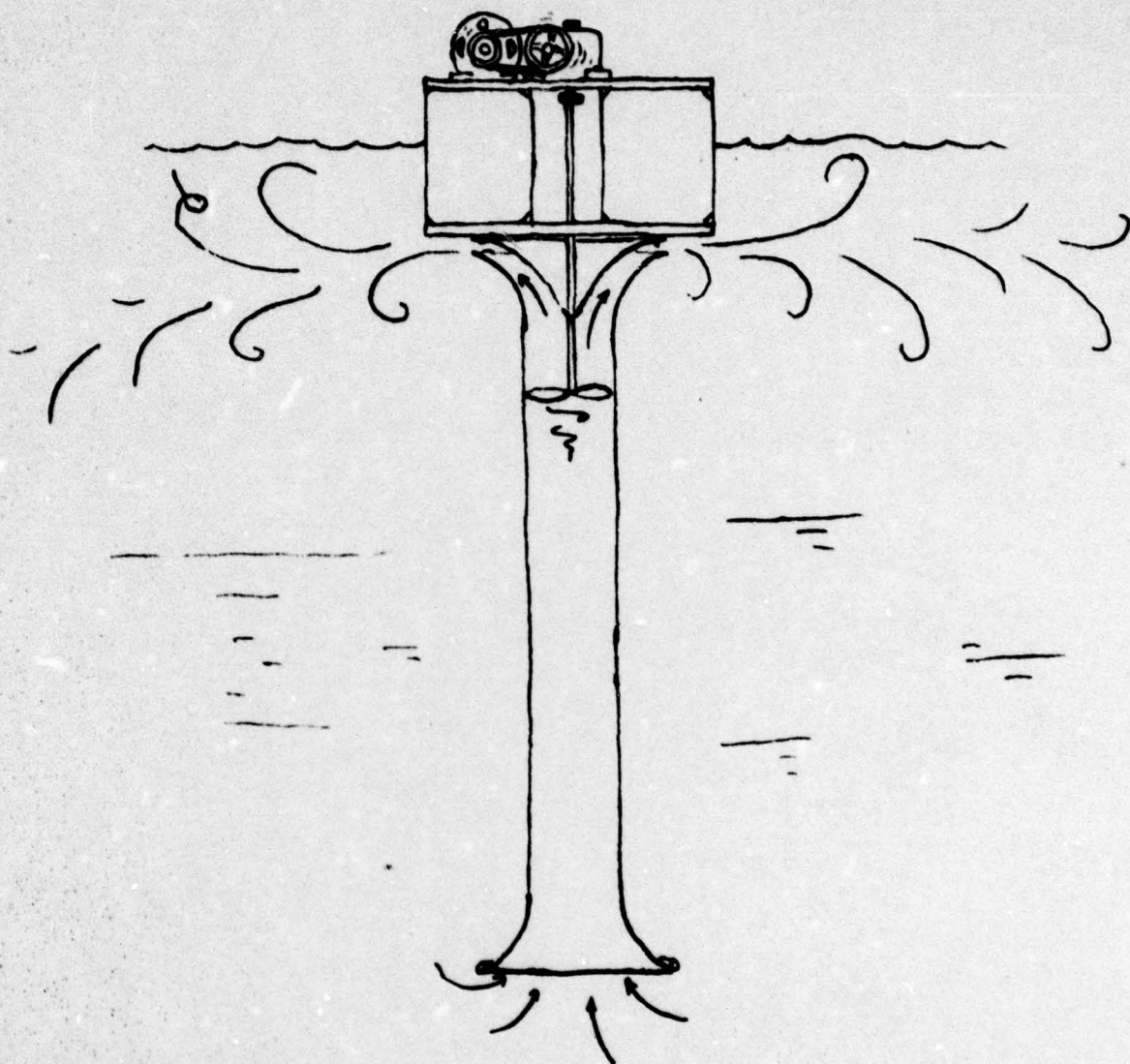
A continuous run of 120 hours was scheduled for the week of 23 July but was terminated after 56 hours following mechanical difficulties. Figures 3 through 10 show temperature-depth relationships at selected times during the 56-hour run. Note the similarity between the final curve of Fig. 2 and the curve of Fig. 3 indicating the permanency of the change in temperature structure by STRATASTIR. The permanency of the change also shows up in Fig. 11, taken 6 hours after the shutdown of STRATASTIR.

Following a shutoff of about 6 weeks STRATASTIR was again operated. Depth-temperature relationships are shown in Fig. 12 to show changes resulting from natural warming of the upper levels by the sun and warm air, and the cooling of the lower levels by inflow from the natural springs in the bottom of the pond. Figure 13 shows the change resulting from the 22-hour run of September 6 and 7.

The inlet opening of STRATASTIR is screened to prevent fish from being drawn into the pump. While there has been no indication of any damage to marine life to date, this aspect is being carefully watched. A reversing motor-starter was installed to allow for reverse flushing of the screened opening. Additional memoranda or reports may be expected on the same subject concerning such items as the quantitative rate of mixing cool and warm water, and possible helpful effects which might be realized for the piscatorial life in a body of water where STRATASTIR is used.

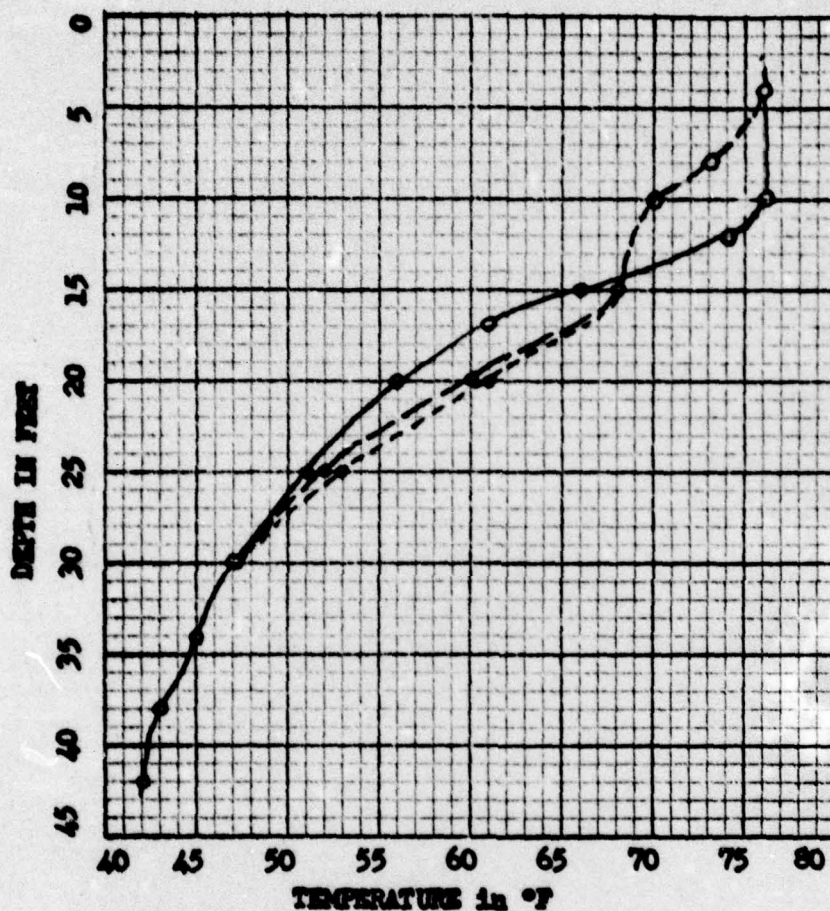


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FIGURE 1 Schematic Diagram of STRATASTIR



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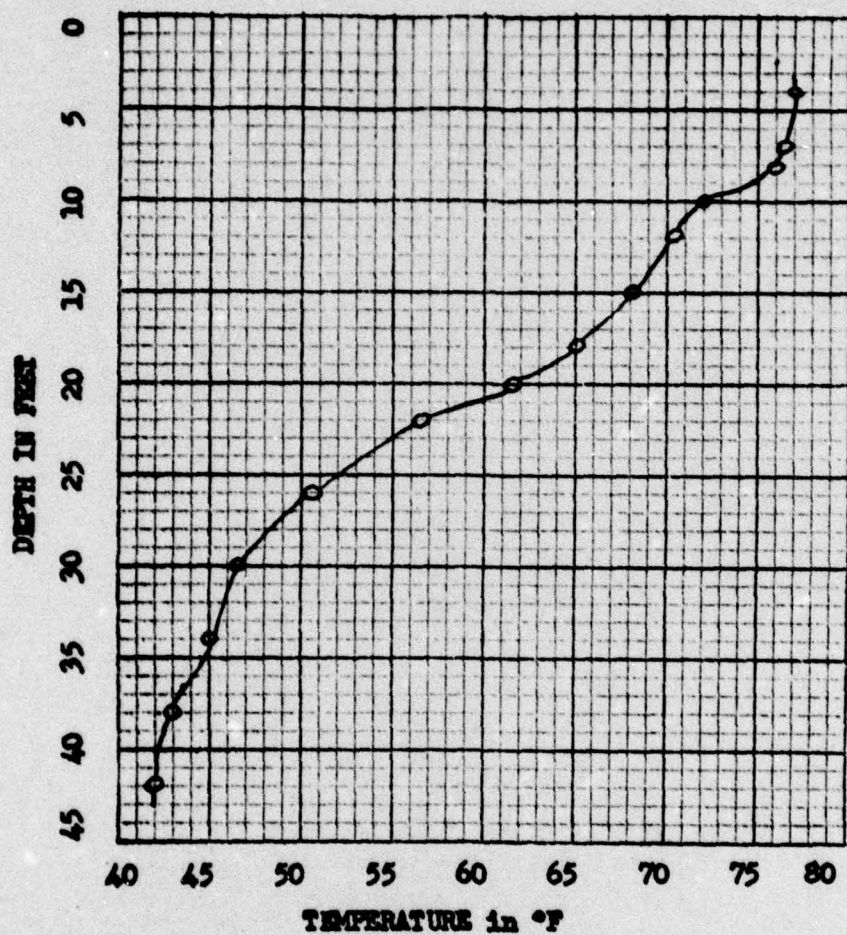
- Natural Conditions 18 July, 1962.
- - - At completion of 4-hour test run.
- · · 20 Hours after completion of run.

NOTE:

STRATASTIR was located over 100 feet from the thermocouples of the multi-point recorder for this test run.

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FIGURE 2 Changes in stratification of Dodge Pond resulting from a 4-hour test run of STRATASTIR.



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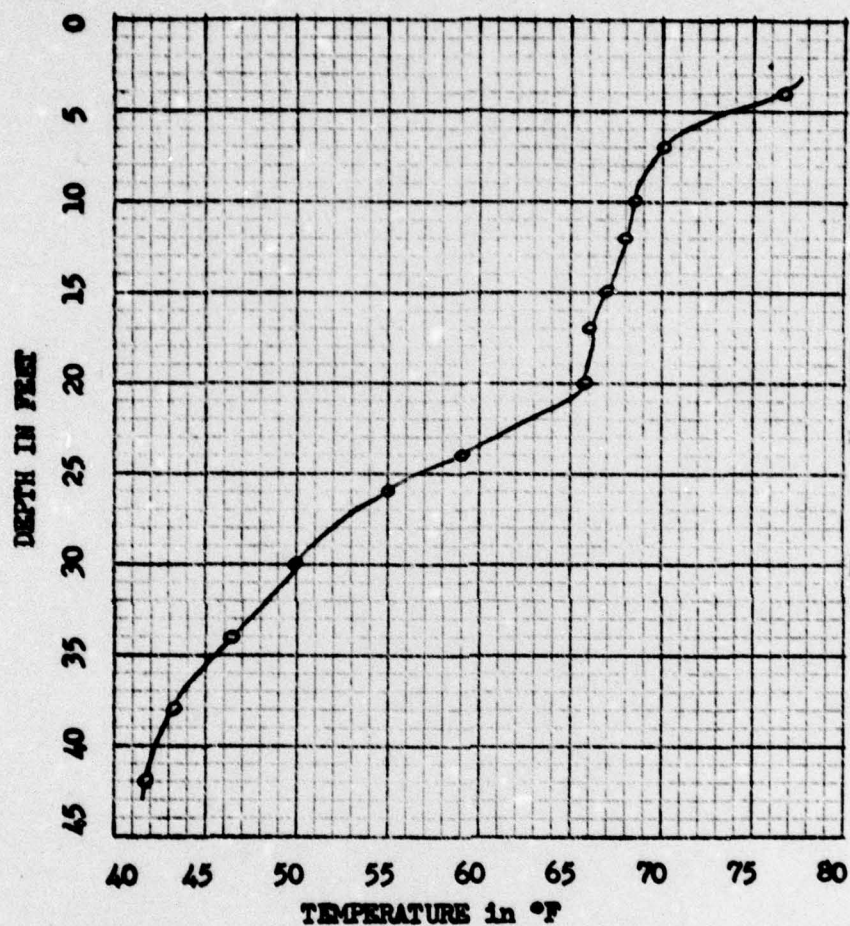
○—○ Temperature vs Depth in Dodge Pond
8:00am 23 July, 1962.

NOTE:

STRATASTIR was located about 80 feet from the thermocouples of the multi-point recorder for the remainder of the figures of this Memo.

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FIGURE 3 Stratification in Dodge Pond at the start of the 56-hour test run.



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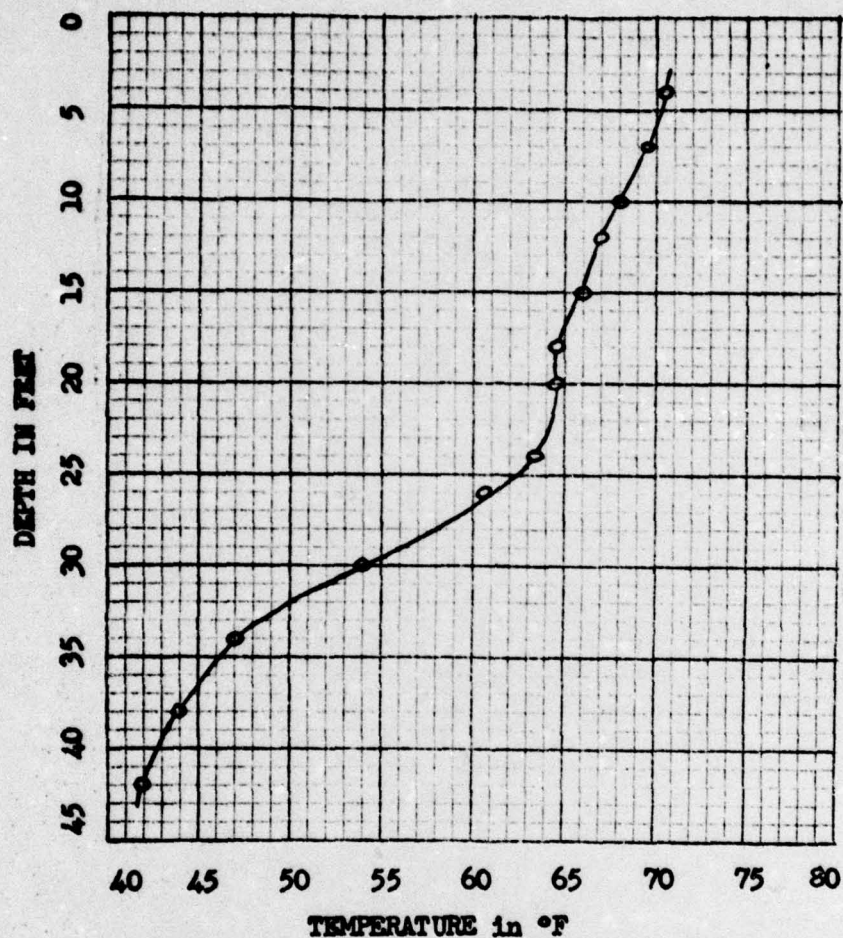
—•— Temperature vs Depth in Dodge Pond
3:00 pm 23 July, 1962

NOTE:

Within a short while after STRATASTIR was started the float was flooded down to provide a discharge depth of 4-1/2 to 5 feet below the water surface. The telescoping section of the inlet was lowered to about 39 feet below the water surface, or about 2 feet above the pond bottom.

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FIGURE 4 Stratification existing after 5 hours of operation.



LEGEND: Temperature vs Depth in Dodge Pond
 —•— 8:00 pm 23 July, 1962.

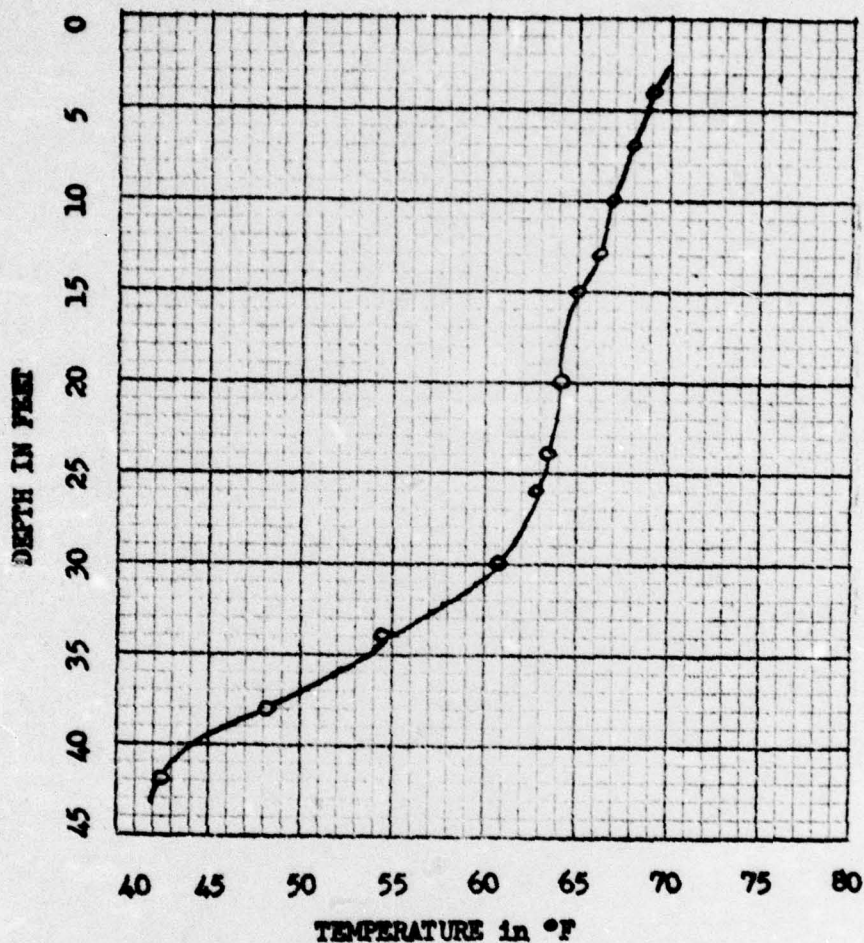
NOTE:

Note reduction of gradient in the 8- to 24-foot zone. Most of the testing taking place at the Field Station is conducted in this zone.

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FIGURE 5 Stratification existing after 10 hours of operation.

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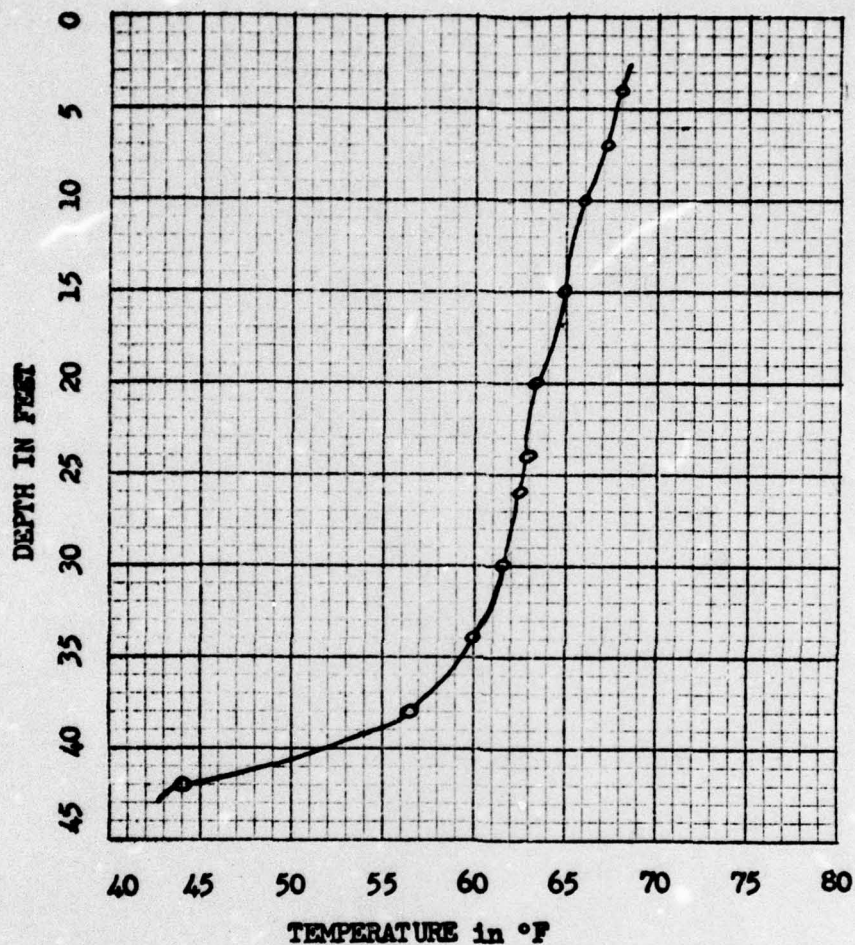
—•— Temperature vs Depth in Dodge Pond
1:00 am 24 July, 1962.

NOTE:

Following lowering of the inlet pipe of STRATASTIR, large schools of fish (Perch, Bluegills, and a few trout about 5 to 9 inches in length) could be seen feeding on a flaky-appearing white material being circulated for perhaps two hours.

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FIGURE 6 Stratification existing after 15 hours of operation.



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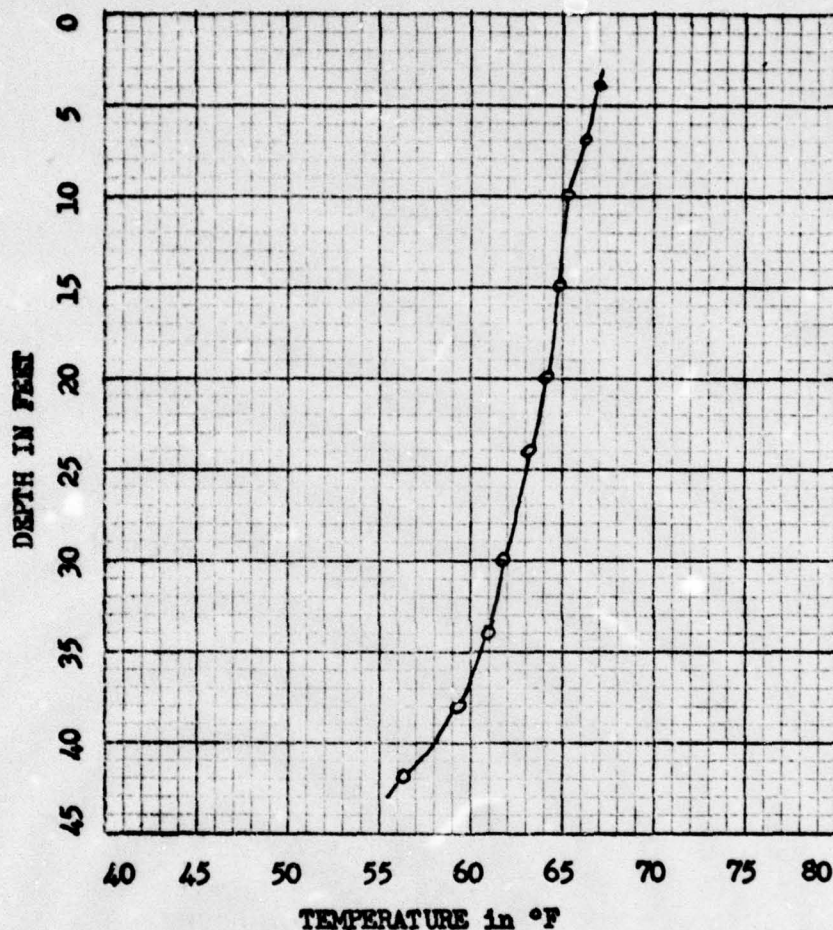
—○— Temperature vs Depth in Dodge Pond
6:00 am 24 July, 1962.

NOTE:

The first several hours of operation of STRATASTIR resulted in a detectable, but relatively small amount of hydrogen sulphide, or similar odorous gas, being released.

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FIGURE 7 Remaining stratification after 20 hours of operation.



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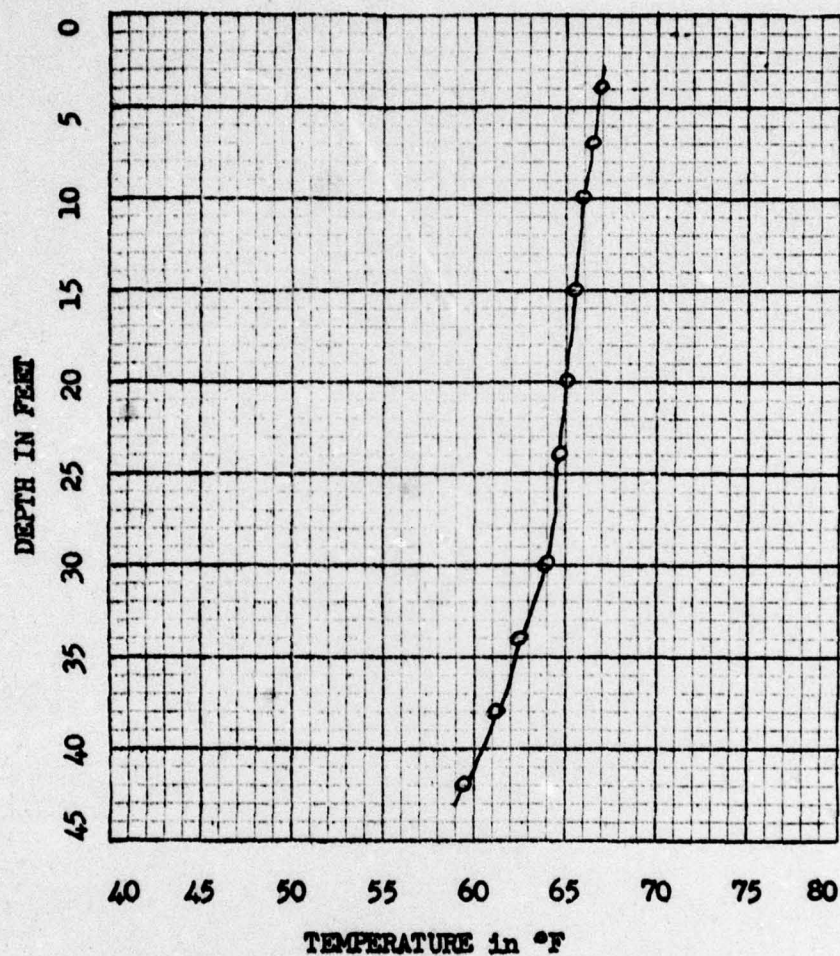
○—○ Temperature vs Depth in Dodge Pond
4:00 pm 24 July, 1962.

NOTES:

Operation of STRATASTIR was sufficiently quiet: no bothersome disturbance of acoustic tests was noted during conduct of the 56-hour test run. Although the inlet of STRATASTIR is 39 feet below the surface, and the pond bottom is 41 feet below the surface, temperature at the 42-foot level is affected.

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FIGURE 8 Reduction of stratification is very marked after 30 hours of operation.



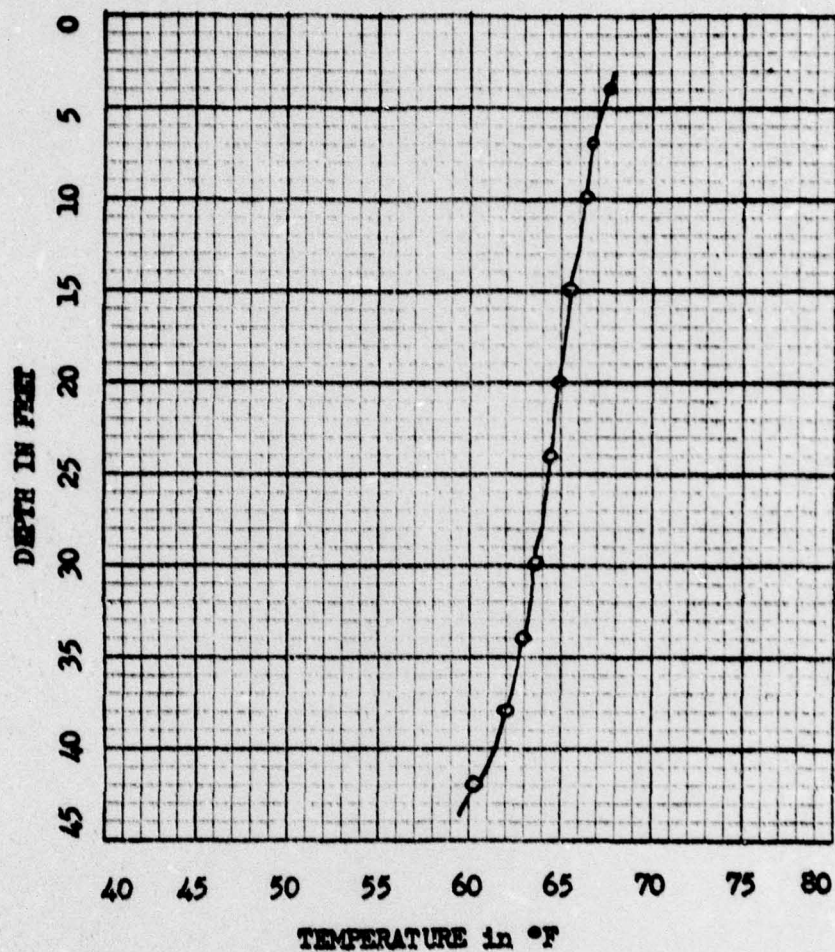
LEGEND: Temperature vs Depth in Dodge Pond
 ○— 2:00 am 25 July, 1962.

NOTE:

It was quite unexpected to have the inlet of STRATASTIR only 2 feet from the mud bottom of Dodge Pond without picking up any mud.

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FIGURE 9 Thermal gradients are almost completely eliminated at the usual working depths after 40 hours of operation.



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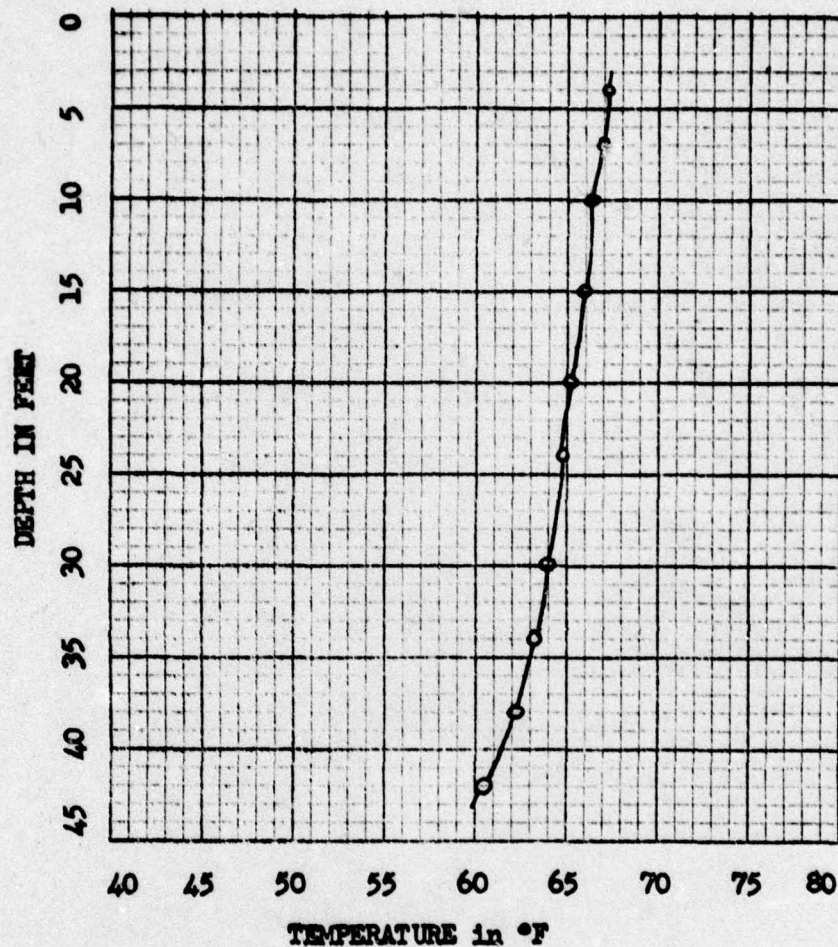
○—○ Temperature vs Depth in Dodge Pond
6:00 pm 25 July, 1962.

NOTE:

Very little real change has occurred during
the last 16 hours of operation.

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FIGURE 10 Thermal conditions in Dodge Pond at
completion of 56-hour test run.



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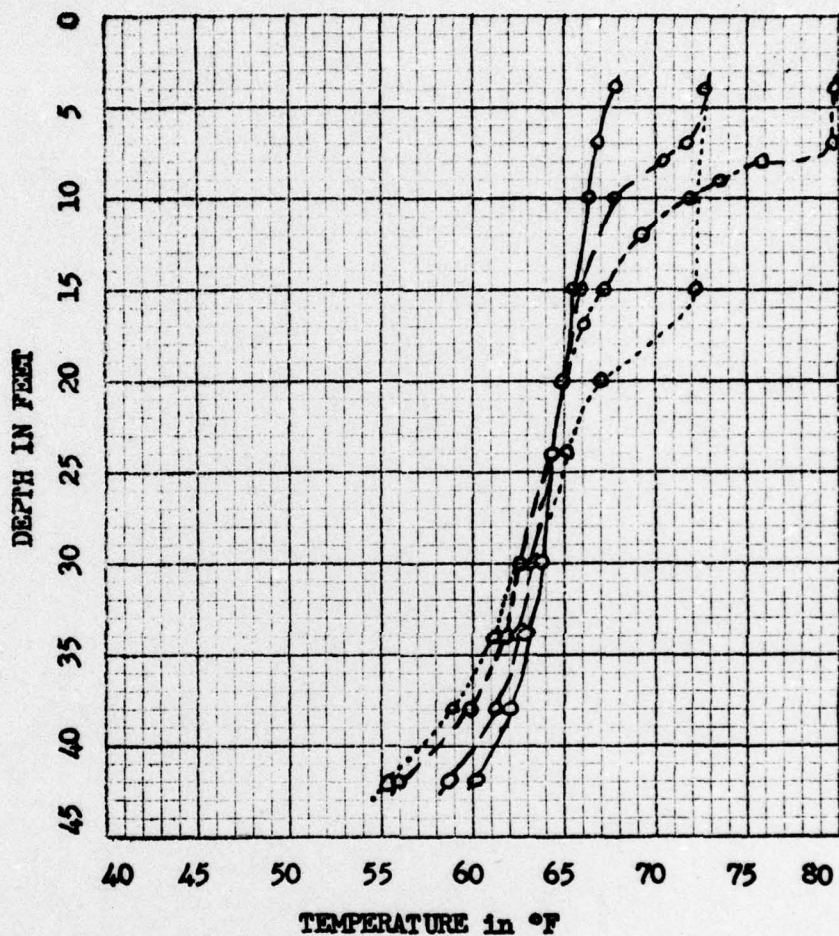
—○— Temperature vs Depth in Dodge Pond
Midnight 25 July, 1962.

NOTE:

There have been no appreciable changes in the temperature - depth structure during the six hours following shutdown of STRATASTIR.

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FIGURE 11 Thermal conditions in Dodge Pond 6 hours after completion of 56-hour test run.



LEGEND:

Temp. vs Depth at noted times following shutdown:

—○— Immediately following shutdown.

---○--- 4 days after shutdown.

.....○..... 2 weeks after shutdown.

-.-.-○-.-.- 6 weeks after shutdown.

NOTES:

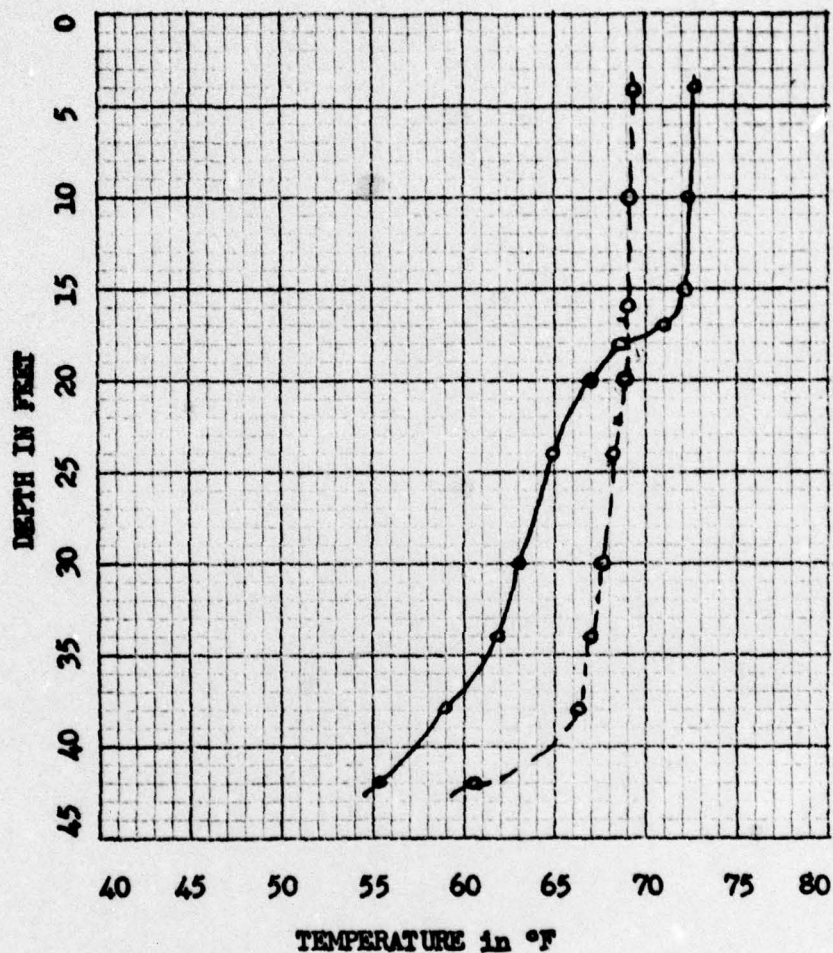
This figure shows natural restratification of the water.

Natural environmental factors caused restratification.

Radiant heat from the sun and the warm air above the water warm the upper levels.

Inflows from submerged springs cool the lower levels.

FIGURE 12 Environmental factors cause some restratification during a six-week period.



LEGEND:

Temperatures vs Depth in Dodge Pond

—○— 10:00 am 6 Sept, 1962.

- - -○- - 8:00 am 7 Sept, 1962.

NOTES:

Required operating time for reducing thermal stratification appears to be approximately proportional to correction needed.

Following the 22-hour operating period required, the temperature difference from 4 feet to 16 feet was only 0.4°F.

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FIGURE 13 Dodge Pond again destratified by STRATASTIR: